INDIANA DEPARTMENT *of* EDUCATION

2023 INDIANA ACADEMIC STANDARDS

MATHEMATICS

GEOMETRY

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Indiana Academic Standards Context and Purpose

Introduction

The Indiana Academic Standards for Geometry are the result of a process designed to identify, evaluate, synthesize, and create high-quality, rigorous learning expectations for Indiana students.

Pursuant to Indiana Code (IC) 20-31-3-1(c-d), the Indiana Department of Education (IDOE) facilitated the prioritization of the Indiana Academic Standards. All standards are required to be taught. Standards identified as essential for mastery by the end of the course are indicated with shading and an “E.” The learning outcome statement for each domain immediately precedes each set of standards.

The Indiana Academic Standards are designed to ensure that all Indiana students, upon graduation, are prepared with essential knowledge and skills needed to access employment, enrollment, or enlistment leading to service.

What are the Indiana Academic Standards and how should they be used?

The Indiana Academic Standards are designed to help educators, parents, students, and community members understand the necessary content for each course, and within each content area domain, to access employment, enrollment, or enlistment leading to service. These standards should form the basis for strong core instruction for all students at each grade level and content area. The standards identify the minimum academic content or skills that Indiana students need in order to be prepared for success after graduation, but they are not an exhaustive list.

While the Indiana Academic Standards establish key expectations for knowledge and skills and should be used as the basis for curriculum, the standards by themselves do not constitute a curriculum. It is the responsibility of the local school corporation to select and formally adopt curricular tools, including textbooks and any other supplementary materials, that align with Indiana Academic Standards. Additionally, corporation and school leaders should consider the appropriate instructional sequence of the standards as well as the length of time needed to teach each standard. Every standard has a unique place in the continuum of learning, but each standard will not require the same amount of time and attention. A deep understanding of the vertical articulation of the standards will enable educators to make the best instructional decisions. These standards must also be complemented by robust, evidence-based instructional practices to support overall student development. By utilizing strategic and intentional instructional practices, other areas such as STEM and employability skills can be integrated with the content standards.

Content-Specific Considerations

The Indiana Academic Standards for Geometry consist of five domains: Geometry Foundations, Triangles, Quadrilaterals and Other Polygons, Circles, and Transformations & Three-Dimensional Solids. The skills listed in each domain indicate what students should know and be able to do by the end of the course. The Process Standards demonstrate the ways in which students should develop conceptual understanding of mathematical content, and the ways in which students should synthesize and apply mathematical skills.

Acknowledgments

The Indiana Department of Education appreciates the time, dedication, and expertise offered by Indiana's K-12 educators, higher education professors, representatives from business and industry, families, and other stakeholders who contributed to the development of the Indiana Academic Standards. We wish to specially acknowledge the committee members, as well as participants in the public comment period, who dedicated many hours to the review and evaluation of these standards designed to prepare Indiana students for success after graduation.

Mathematics Process Standards

PS.1: Make sense of problems and persevere in solving them.
Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway, rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” and "Is my answer reasonable?" They understand the approaches of others to solving complex problems and identify correspondences between different approaches. Mathematically proficient students understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
PS.2: Reason abstractly and quantitatively.
Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.
PS.3: Construct viable arguments and critique the reasoning of others.
Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They analyze situations by breaking them into cases and recognize and use counterexamples. They organize their mathematical thinking, justify their conclusions and communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. They justify whether a given statement is always true, sometimes, or never. Mathematically proficient students participate and collaborate in a mathematics community. They listen to or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.
PS.4: Model with mathematics.
Mathematically proficient students apply the mathematics they know to solve problems arising in everyday life, society, and the workplace using a variety of appropriate strategies. They create and use a variety of representations to solve problems and to organize and communicate mathematical ideas. Mathematically proficient students apply what they know and are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts, and formulas. They analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

PS.5: Use appropriate tools strategically.
Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Mathematically proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. Mathematically proficient students identify relevant external mathematical resources, such as digital content, and use them to pose or solve problems. They use technological tools to explore and deepen their understanding of concepts and to support the development of learning mathematics. They use technology to contribute to concept development, simulation, representation, reasoning, communication, and problem solving.
PS.6: Attend to precision.
Mathematically proficient students communicate precisely to others. They use clear definitions, including correct mathematical language, in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They express solutions clearly and logically by using the appropriate mathematical terms and notation. They specify units of measure and label axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently and check the validity of their results in the context of the problem. They express numerical answers with a degree of precision appropriate for the problem context.
PS.7: Look for and make use of structure.
Mathematically proficient students look closely to discern a pattern or structure. They step back for an overview and shift perspective. They recognize and use properties of operations and equality. They organize and classify geometric shapes based on their attributes. They see expressions, equations, and geometric figures as single objects or as being composed of several objects.
PS.8: Look for and express regularity in repeated reasoning.
Mathematically proficient students notice if calculations are repeated and look for general methods and shortcuts. They notice regularity in mathematical problems and their work to create a rule or formula. Mathematically proficient students maintain oversight of the process, while attending to the details as they solve a problem. They continually evaluate the reasonableness of their intermediate results.

Geometry

Standards identified as essential for mastery by the end of the course are indicated with gray shading and an "E." The learning outcome statement for each domain immediately precedes each set of standards.

Geometry Foundations	
Learning Outcome: Students apply the logic of geometric proofs, including in core concepts related to angles and lines.	
G.GF.1	Describe the structure of and relationships within an axiomatic system (undefined terms, definitions, axioms and postulates, methods of reasoning, and theorems) and explain differences among supporting evidence, counterexamples, and actual proofs. (E)
G.GF.2	State, use, and examine the validity of the converse, inverse, and contrapositive of conditional ("if – then") and bi-conditional ("if and only if") statements.
G.GF.3	Develop geometric proofs, including those involving coordinate geometry, using two-column, paragraph, and flow chart formats.
G.GF.4	Prove, construct, and apply theorems about parallel and perpendicular lines, parallel lines and transversals, vertical angles, and perpendicular bisectors. (E)
G.GF.5	Determine if a pair of lines are parallel, perpendicular, or neither by comparing the slopes in coordinate graphs and equations. (E)
G.GF.6	Use tools to explain and justify the process to construct congruent segments and angles, angle bisectors, perpendicular bisectors, altitudes, medians, parallel and perpendicular lines, and parallel lines and transversals.
G.GF.7	Develop the distance formula using the Pythagorean Theorem. Find the lengths and midpoints of line segments in the two-dimensional coordinate system. (E)
Triangles	
Learning Outcome: Students solve real-world and mathematical problems involving triangles, including proofs of theorems and definitions of trigonometric ratios.	
G.T.1	Prove and apply theorems about triangles, including: a. Interior angles of a triangle sum to 180° b. The Isosceles Triangle Theorem and its converse c. The Pythagorean Theorem d. The segment joining midpoints of two sides of a triangle is parallel to the third side and half the length e. A line parallel to one side of a triangle divides the other two proportionally, and its converse f. The Angle Bisector Theorem g. Triangle inequality h. Inequality in one triangle i. Hinge Theorem and its converse (E)

G.T.2	Prove and apply criteria for triangle congruence (ASA, SAS, AAS, SSS, and HL) from the definition of congruence in terms of rigid motions. (E)
G.T.3	Use the definition of similarity in terms of similarity transformations to determine if two given triangles are similar. Explore and develop the meaning of similarity for triangles.
G.T.4	Use congruent and similar triangles to solve real-world and mathematical problems involving sides, perimeters, and areas of triangles. (E)
G.T.5	Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.
G.T.6	Use trigonometric ratios (sine, cosine, tangent, and their inverses) and the Pythagorean Theorem to solve real-world and mathematical problems involving right triangles. (E)
G.T.7	Use the relationship between the sides of special right triangles (30° - 60° and 45° - 45°) to solve real-world and other mathematical problems. (E)
Quadrilaterals & Other Polygons	
Learning Outcome: Students solve real-world and mathematical problems involving regular and irregular polygons, including proofs of theorems.	
G.QP.1	Prove and apply theorems about parallelograms, including those involving angles, diagonals, and sides. (E)
G.QP.2	Prove that given quadrilaterals are parallelograms, rhombuses, rectangles, squares, kites, or trapezoids. Include coordinate proofs of quadrilaterals in the coordinate plane.
G.QP.3	Develop and use formulas to find measures of interior and exterior angles of polygons.
G.QP.4	Compute perimeters and areas of regular and irregular polygons to solve real-world and other mathematical problems. (E)
Circles	
Learning Outcome: Students solve real-world and mathematical problems involving circles.	
G.CI.1	Define, identify, and use relationships among the following: radius, diameter, arc, measure of an arc, chord, secant, tangent, congruent circles, and concentric circles.
G.CI.2	Explore and use relationships among inscribed angles, radii, and chords, including the following: a. The relationship that exists between central, inscribed, and circumscribed angles; b. Inscribed angles on a diameter are right angles; and c. The radius of a circle is perpendicular to a tangent where the radius intersects the circle.
G.CI.3	Solve real-world and other mathematical problems that involve finding measures of circumference, areas of circles and sectors, and arc lengths and related angles (central, inscribed, and intersections of secants and tangents). (E)

Transformations & Three-Dimensional Solids	
Learning Outcome: Students solve real-world and mathematical problems involving transformations of figures and three-dimensional solids.	
G.TS.1	Use geometric descriptions of rigid motions to transform figures and to predict and describe the results of translations, reflections and rotations on a given figure. Describe a motion or series of motions that will show two shapes are congruent. (E)
G.TS.2	Verify experimentally the properties of dilations given by a center and a scale factor. Understand the dilation of a line segment is longer or shorter in the ratio given by the scale factor.
G.TS.3	Explore properties of congruent and similar solids, including prisms, regular pyramids, cylinders, cones, and spheres, and use them to solve problems.
G.TS.4	Solve real-world and other mathematical problems involving volume and surface area of prisms, cylinders, cones, spheres, and pyramids, including problems that involve composite solids and algebraic expressions. (E)
G.TS.5	Apply geometric methods to create and solve design problems. (E)